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INTRA-TYMPANIC PRESSURE DURING PHONATION.

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The two principal factors in the production of articulate sounds being the expulsion of air from the lungs, and the variations in position of different parts of the larynx, naso-pharyngeal and buccal cavities, changes in the degree of pressure in these cavities necessarily result and play an important part in the production of articulate sounds.

This subject has been considered by Dr. Henry J. Bigelow, in his experiments on articulation in cases of cleft palate, as the result of which he has given rules for practice in phonation which should enable the patient, by varying the pressure in the buccal cavity, to accommodate the position of the tongue and lips to the abnormal condition of the roof of the mouth, and thereby increase the clearness of articulation.* It is evident that under normal conditions the changes in the contour of the buccal cavity during phonation result in corresponding variations of pressure in the mouth and in the naso-pharyngeal space; and the case in which the following tests were made proves conclusively that this pressure is sufficient to be communicated through the Eustachian tube to the middle ear: —

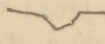
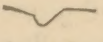
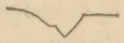
The patient, a man thirty years of age, had a purulent inflammation of the left middle ear, the result of an attack of scarlet fever in his fourth year. Up to the time when first examined, the purulent discharge had continued, in varying quantity, for twenty-four years. Examination of the ear

* Boylston Prize Dissertation, 1844.

showed almost entire destruction of the membrana tympani, and a granular condition of the mucous membrane of the tympanic cavity, with well-marked polypoid granulations about the head of the malleus and incus, and hanging down into the cavity. As the result of careful cleansing, the use of astringents, and the application of caustics, the granulations disappeared, the discharge diminished, and a cicatricial growth, starting from the periphery of the membrane and from about the malleus, formed a septum between the lower and anterior portion of the tympanic cavity and the outer ear.

This septum, as is the case in cicatrices of the membrana tympani, was thinner than the membrana tympani itself, and its larger segment, extending across the anterior portion of the tympanic cavity opposite the opening of the Eustachian tube, was exceedingly lax and could be easily made to bulge outward by forcing air up through the Eustachian tube.

About the 1st of June, 1875, the patient appeared, speaking very much as if he were suffering from a "cold in the head"; that is, the m, n, and ng sounds were pronounced b, d, and g; "manner," for instance, was pronounced "badder," with a very slight nasal sound, and "managing," "badagig." There were no other symptoms of a cold, however, and he explained the peculiar pronunciation as a voluntary effort to suppress the nasal sounds, m, n, and ng, substituting the corresponding media, because the former were accompanied by a very disagreeable crackling and bursting sound in the left ear. This sound was less on pronouncing m, greater on pronouncing n, and most disagreeable of all on pronouncing ng. An examination of the left ear while the patient sounded the nasal checks, showed that, with each sound, the lax cicatrix extending across the tympanic orifice of the Eustachian tube executed a corresponding movement. With m, the membrane made a slight excursion outward and fell back into its former position; with n, the excursion was still greater; and with ng, a double excursion was observed, the membrane only partially resuming its original position between the two movements.

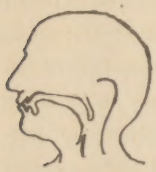
The movements of the membrane as to duration and extent of the excursion being represented by the following curves, which correspond very nearly to the logographic tracings of m, n, and ng, — thus, m,  n,  ng, 

By pressing a probe against the membrane its excursions were partially controlled, and the unpleasant sensations in the ear correspondingly diminished. A piece of cotton tightly packed at the bottom of the meatus was still more effectual, but this improvement lasted only a few hours, as the cotton was easily displaced. As a final remedy, a portion of the membrane was excised, leaving a circular opening, through which air forced through the Eustachian tube passed freely. The movements of the membrane immediately ceased, the nasal sounds were pronounced clearly and with the usual resonance; and the opening remaining, up to the last examination, there had been no return of the unpleasant symptoms in the ear, and the voice was as clear as usual.

Immediately after the operation and for the purpose of experiment, a manometer made of barometer tube bent into U form, and having a bore 1 millimetre in diameter, filled with water, was inserted in the outer ear, closing the opening. The pronunciation of the nasal checks produced a movement in the column of fluid exactly corresponding to the movement of the membrane before perforation: for the m sound, there was a rise and fall of the column $\frac{1}{2}$ millimetre; for the n sound, a rise and fall of nearly 1 mm.; and for the ng sound, a double rise and fall for nearly the same degree. The tube was then placed in one nostril and the other nostril closed; for the m sound, the column rose 16 millimetres, for the n sound, 20 mm., and for the final impulse of the ng sound, with the same double movement as before, 26 millimetres.

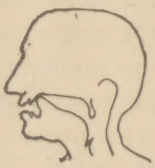
The same test, in a patient having no perforation of the membrana tympani, showed the same proportion of movement for the several nasal checks. The movements of the membrane in the case described, and of the manometric column, when the

tube was placed in the ear, show a certain pressure in the naso-pharyngeal space, corresponding to each of the three nasal sounds, and an examination into the position of the lips, tongue, and palate, in the production of m, n, and ng, shows a corresponding diminution of the capacity of the buccal cavity. Thus, in producing m, the position is as follows: —

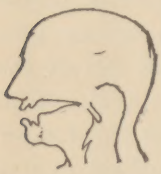


The lips closed and tongue depressed. The capacity of the buccal cavity being considerable, and the pressure in the naso-pharyngeal cavity correspondingly small. This is shown by the lesser movement of the membrane in the ear, and of the fluid column in the manometer.

In producing n, the lips are slightly apart, and the tip of the tongue pressed against the hard palate, just behind the teeth. The capacity of the buccal cavity is diminished, and the pressure in the naso-pharyngeal space proportionately greater, as shown by the greater movement of the membrane in the ear and the manometric column.



In producing ng, the top and back of the tongue are pressed upward, still further diminishing the resonant capacity of the buccal cavity, and allowing the full force employed in the production of the sound to expend itself in the nares and naso-pharyngeal cavity, back of the elevated tongue.



Helmholz says, "m and n resemble the vowels in their formation, because they cause no noise in the buccal tube. The buccal tube is shut and the voice escapes through the nose. The mouth only forms a resonating cavity modifying the sound." As we have seen, in m the buccal cavity is closed at its farthest anterior limit by the lips, and the cavity has full resonance. In sounding n, it is closed by the tip of the tongue a little farther backward and its resonant capacity diminished, while in the full nasal sound, ng, it is closed at its posterior limit by the elevation of the top

and back of the tongue, and its resonant capacity is very little.

Merkel* tested the pressure in the nasal cavity by holding a bit of down or a light feather in front of the nostrils. On sounding a pure vowel the feather remained motionless, the air passing out through the buccal cavity; but on sounding a nasal tone, the feather was set in motion.

Max Müller† says, b, d, and g, may be modified to m, n, and ng; for these nasals a full contact takes place (that is, of lips or tongue and roof of mouth), but the breath is stopped, — not abruptly (as in p, t), but in the same manner as with the media (as in b, d, g), — at the same time the breathing is emitted through the nose. In the present case the unpleasant sensation in the ear caused the patient to seek relief by substituting the media, b, d, and g, for the nasal tones, thus allowing the air to pass out through the mouth and diminishing the pressure in the pharynx and Eustachian tube and ear. In the formation of the nasal tones, in this case, it has been interesting to note an increase of pressure in these parts proportionate to the degree of closure of the buccal cavity; and the case suggests a series of tests of the distribution of pressure in the formation of consonant sounds, which would certainly be of interest and possibly of value.

* Der Kehlkopf, p. 268. † Science of Language, p. 158.